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0201423.1 23 JAN 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

SOUTH BANK UNIVERSITY ENTERPRISES LIMITED
103 BOROUGH ROAD
LONDON SE1 0AA
GB

Patents ADP number *(if you know it)*

6543714001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

IMPROVED METHOD AND EQUIPMENT FOR MEASURING VAPOUR FLUX FROM SURFACES

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

COHEN, ALAN NICOL
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TATSFIELD
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Patents ADP number *(if you know it)*

6963557001

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Number of earlier application	Date of filing *(day / month / year)*

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Continuation sheets of this form	—
Description	9
Claim(s)	4
Abstract	1
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11. I/We request the grant of a patent on the basis of this application.

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Date 22/01/02

12. Name and daytime telephone number of person to contact in the United Kingdom — A. N. Cohen 01959 577172

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Improved Method and Equipment for Measuring Vapour Flux from Surfaces

The present invention relates to a method and a device for measuring vapour flux from a surface, more particularly it relates to a method and a device which can be used to measure the rate of water loss from human skin.

The transepidermal water loss (TEWL) is important in the evaluation of the efficiency of the skin/water barrier. Damage to the skin resulting from various skin diseases, burns and other damage can affect the TEWL and measurement of the TEWL can indicate such damage and possibly its early onset or response to treatment. It therefore has potential for use in clinical diagnosis.

As the TEWL is a measure of the effectiveness of the skin/water barrier its measurement is important in prematurely born infants, when dehydration due to excessive water loss can have serious adverse results. The TEWL is also used in testing the effect of pharmaceutical and cosmetic products applied to the skin.

GB patent 1532419 describes an instrument for measuring the rate of water loss from the skin in which an open measurement cylinder containing two spaced apart relative humidity sensors and two associated temperature sensors is placed on the skin so that water vapour escaping from the skin diffuses along the length of the measurement cylinder and passes the sensors. The output from these sensors can be used to measure the water vapour concentration gradient (or equivalently the water vapour density gradient or water vapour pressure gradient) in the measurement cylinder and hence the water vapour flux from the skin.

Patent Application WO 00/03208 describes an instrument which uses a measurement chamber in the form of a cylinder which is open at one end and closed at the other end, in order to protect the diffusion zone within it from disturbance by ambient air movements. The open end is placed in contact with the surface of interest while the

internal surface of the closed end is cooled to a stable and known temperature at which the water vapour in its vicinity condenses to liquid water or ice. In the absence of bulk air movements within the measurement cylinder, the vapour entering the measurement cylinder from the surface of interest will diffuse towards the cooled surface, where it will condense, producing a gradient of vapour concentration within the measurement cylinder, parallel to its axis. The vapour flux is measured by measuring this gradient. Unlike the instrument of GB 1532419, this instrument will function with a single measurement of vapour concentration, typically half way between the surface of interest and the condensing surface, because the vapour concentration at the condensing surface itself can be calculated from its known temperature.

Patent Application WO 00/03208 also provides for sensors other than those for relative humidity and associated temperature conventionally used for measuring water vapour concentration, such as opto-electronic sensors to be used. It also provides for vapour fluxes other than water vapour flux to be measured by using appropriate sensors of vapour concentration. For generality, conciseness and clarity, all types of sensor or sensor combination for measuring vapour concentration will be referred to hereinafter, where appropriate, as *vapour concentration* sensors.

The method of construction of both these instruments has several drawbacks. The sensors are generally mounted by means of thin wires from one side of the measurement cylinder. They therefore obstruct the bore of the measurement cylinder and their physical size limits the size of the smallest bore that can be implemented and the spacing and number of sensors that can be accommodated. Furthermore, these sensors obstruct the path of the water vapour diffusing through the measurement cylinder, which has the effect of reducing measurement sensitivity. The construction also lacks ruggedness and makes it difficult to achieve reliable seals around the wires. Another difficulty is the positioning of the sensors in a precise and reproducible geometry, and to maintain this geometry over prolonged use, as the sensors are

exposed to damage and misalignment through shock, vibration and contact with objects small enough to fit into the measurement cylinder. Also, with the sensors obstructing the bore of the measurement cylinder, cleaning of the inner wall of the measurement cylinder becomes difficult.

We have now invented an improved method and instrument.

According to the invention there is provided equipment for measuring the water vapour flux from a surface which equipment comprises a measurement cylinder with a first end which is adapted to be placed against the surface and at least one vapour concentration sensor from which the gradient of water vapour concentration and hence the flux of water vapour from the surface can be calculated, which sensor(s) is(are) positioned adjacent the wall of the measurement cylinder.

Adjacent the wall of the measurement cylinder means adjacent the inside or outside walls of the measurement cylinder and all points in between. Each such vapour concentration sensor is in contact with vapour inside the measurement cylinder and, when the sensor is positioned inside the measurement cylinder, it is preferably mounted in the wall, so that the sensor is as close to the wall as practical. In practice the sensor can project a small distance into the measurement cylinder depending on its size and other considerations.

When such a vapour concentration sensor is mounted on the outside of the measurement cylinder there is preferably a hole through the wall of the measurement cylinder, if necessary, to permit the sensor not mounted on the inside to be exposed to the air and water vapour within the measurement cylinder. If the dimensions are suitable the sensor can be mounted substantially or partially inside the wall in such a hole. Such a hole should be sealed against the atmosphere outside the measurement cylinder.

Preferably the vapour concentration sensors are positioned approximately symmetrically about the mid-way point between the ends of the measurement cylinder.

The invention relies on a distribution of vapour concentration within the measurement cylinder which is substantially uniform within planes perpendicular to its axis.

Therefore, any gradient of water vapour concentration parallel to the axis of the measurement cylinder, associated with a finite flux of water vapour diffusing within it, will manifest itself in a similar way along any line parallel to the axis of the measurement cylinder, irrespective of radial position within its bore. Furthermore, given that the transport mechanism for the water vapour within the measurement cylinder is diffusion, the water vapour can migrate through any small holes in the side wall of the measurement cylinder, thus allowing a vapour concentration sensor to be mounted within the wall or on the outside of the measurement cylinder. If such a hole is sealed beyond the position of the sensor, then there can be no net flux of water vapour migrating through it in the steady state. The vapour concentration gradient along the bore of such a hole will therefore be zero and the vapour concentration sensed at any position along such a bore will be substantially the same as the vapour concentration at the inside wall of the measurement cylinder.

It is recognised in the above that the relative humidity and temperature within the measurement cylinder are not uniform, but change with both axial and radial co-ordinates. Therefore, the readings of any relative humidity and temperature sensors located close to the axis of the measurement cylinder will generally differ from those of similar sensors with similar axial co-ordinate, but located at or within the wall of the measurement cylinder. However, local values of relative humidity and temperature can be used to calculate water vapour concentration, which value will be substantially independent of radial position. The vapour flux can therefore be

determined by the vapour concentration gradient method, irrespective of the radial position of the sensors.

It is also recognised that the time taken for steady conditions of water vapour concentration along a small hole in the wall of the measurement cylinder is finite and may decrease the response speed of the instrument. The variables that affect this time are the length of the hole parallel to its axis, the diameter of the hole and the volume of any cavity terminating the hole in the region of the sensor(s). With careful design, this response time can be made sufficiently small for its contribution to the overall response speed of the instrument to become unimportant.

In one embodiment, an open measurement cylinder containing two spaced apart vapour concentration sensors adjacent the wall of the measurement cylinder is placed on the skin so that water vapour escaping from the skin diffuses along the measurement cylinder and passes the sensors. The output from these sensors can be used to measure the water vapour concentration gradient in the measurement cylinder and hence the water vapour flux from the skin.

In another embodiment, a measurement cylinder which is closed at one end and containing at least one vapour concentration sensor adjacent the wall of the measurement cylinder, is placed with its open end in contact with the skin so that water vapour escaping from the skin diffuses along the measurement cylinder and passes the sensor. The internal surface of the closed end is cooled to a stable and known temperature at which the water vapour in its vicinity condenses to liquid water or ice. In the absence of bulk air movements within the measurement cylinder, the vapour entering the measurement cylinder from the skin surface will diffuse towards the cooled surface, where it will condense, producing a gradient of vapour concentration within the measurement cylinder, parallel to its axis. The vapour flux is measured by measuring this gradient. Unlike the instrument of the first embodiment, this instrument will function with a single measurement of vapour concentration,

typically half way between the skin surface and the condensing surface, because the vapour concentration at the condensing surface itself can be calculated from its known temperature.

The closed surface of the measurement cylinder can be cooled by conventional cooling means and preferably uses an electrical cooling means e.g. one based on the Peltier effect. This enables the cooling to be accurately controlled at the requisite level quickly and easily.

The water which is condensed at the cold surface can be re-evaporated by heating the surface during times when the instrument is not being used for measurement. If the cooler is a Peltier device, then this can conveniently be accomplished by reversing the current flow through it.

A suitable and convenient choice of vapour density sensor is a combination of sensors for relative humidity and associated temperature. A suitable and convenient choice of relative humidity sensor includes sensors based on the change in capacitance or change in electrical conductivity etc, which are widely commercially available. A suitable and convenient choice of temperature sensor includes the conventional thermocouple and thermistor, which are widely commercially available. Alternatively a composite sensor can be used which simultaneously measures the relative humidity and the associated temperature so that one such composite sensor can produce the required signals.

An additional temperature sensor is preferably placed in contact with the cold surface in order both to maintain its temperature at a constant value and to provide a temperature reading from which the concentration of water vapour in its immediate vicinity can be calculated.

Preferably the outputs from the sensors are fed to a processing device such as a microprocessor or PC, which is programmed to convert the signals from the sensors to the required type of output or readout. By this means a user of the equipment can obtain a result in a form which requires little further processing and can be interpreted easily e.g. the flux of water vapour can be directly displayed.

The cylinder is the common geometry of measurement chamber for such instruments, but any convenient shape can be used e.g. rectangular parallelepiped, prism, etc. The measurement chamber is preferably made of compact size so that it occupies a small area and can easily be placed on the surface of interest, e.g. the skin at the desired location of a TEWL measurement. The measurement chamber can conveniently be constructed in the form of a wand or with a convenient handle etc.

The equipment and method can be used to measure any vapour flux from a surface although, when the vapour is not water vapour, the sensor(s) and cold plate temperature are chosen accordingly and, apart from skin, the equipment can be used to measure water vapour flux from other surfaces, including wood, concrete, bricks, paper, plant leaves, etc.

The invention is illustrated in the accompanying drawings in which

Fig. 1 is a view of a prior art device and
Fig. 2 is a view of a device of the invention

Referring to fig. 1 this shows part of the wall of an instrument for measuring the vapour flux from a surface. A measurement cylinder has a wall (2) and an axis shown by line (1). There is a combined relative humidity and temperature sensor, consisting of a relative humidity sensor (3) and temperature sensor (4) shown mounted close to the axis of the cylinder, supported by two pairs of wires (5), which also act to transmit the electrical signals from the individual sensors to the signal processing

electronics (not shown). In use the sensor combination measures the relative humidity and associated temperature to measure the water vapour flux from the skin. The measurement cylinder is placed against the skin as shown and the closed surface (not shown) is cooled down to a sufficiently low temperature to maintain a substantially lower water vapour concentration in its immediate vicinity than in the immediate vicinity of skin at the other end of the measurement cylinder.

A computer is programmed with a program so that the output from the sensors (3) and (4) are converted to a reading in the desired form, e.g. water vapour flux from the surface.

After a short period of time (to allow for steady state conditions to be attained inside the measurement cylinder) the readings are evaluated by the computer. Alternatively, readings can be taken continuously or periodically in order to record the time change of the signals and the water vapour flux calculated according to suitable criteria. As can be seen the sensors and the associated wires obstruct the bore of the measurement cylinder and their physical size limits the size of the smallest bore that can be implemented. Furthermore, these sensors obstruct the path of the water vapour diffusing through the measurement cylinder, which has the effect of reducing measurement sensitivity.

Referring to fig. 2, the axis of the cylindrical measurement chamber is shown by a line (1), and part of the wall of the cylindrical measurement chamber is shown at (12). The RHT sensor combination, consisting of a relative humidity sensor (13) and a temperature sensor (14) is shown mounted against the outer wall of the measurement cylinder in such a way as to prevent ingress of air and water vapour from the ambient atmosphere. A small hole (15) allows air and water vapour within the measurement cylinder to reach the sensors.

In use the temperature and relative humidity is measured as in the embodiment of fig. 1 and, as can be seen, the sensors and the associated wires do not obstruct the bore of the measurement cylinder and their physical size does not affect the size of the smallest bore that can be implemented. Furthermore, these sensors cannot obstruct the path of the water vapour diffusing through the measurement cylinder, thus increasing measurement sensitivity.

Claims

1. Equipment for measuring the water vapour flux from a surface which equipment comprises an open measurement cylinder containing two spaced apart relative humidity sensors and two associated temperature sensors, which sensors are positioned adjacent the wall of the measurement cylinder. In use, one end of the measurement cylinder is placed on the surface of interest so that water vapour escaping from this surface diffuses along the measurement cylinder and passes the sensors. The output from these sensors can be used to measure the water vapour concentration gradient in the measurement cylinder and hence the water vapour flux from the skin.

2. Equipment as claimed in claim 1 in which the sensors are mounted adjacent to the inside wall of the measurement cylinder.

3. Equipment as claimed in claim 1 in which the sensors are mounted on the outside of the measurement cylinder and there is a hole through the wall of the measurement cylinder which hole and sensors are sealed against the atmosphere outside the measurement cylinder.

4. Equipment as claimed in claim 1 in which there is a hole through the measurement cylinder wall and the sensors are mounted at least partially within such hole and the hole is sealed against the atmosphere outside the measurement cylinder.

5. Equipment as claimed in any one of claims 1 to 4 in which there are two or more relative humidity sensors and associated temperature sensors axially spaced apart and positioned adjacent the wall of the measurement cylinder.

6. Equipment as claimed in claims 1 to 4 in which there are sensors able to measure the relative humidity and the associated temperature, meaning the temperature substantially at the location of the relative humidity sensor.

7. Equipment as claimed in any one of claims 1 to 4 in which the sensors are a composite construction which simultaneously measure relative humidity and associated temperature.

8. Equipment as claimed in any one of claims 1 to 4 in which the sensors for measuring relative humidity are based on the change in capacitance or change in electrical conductivity.

9. A method for measuring the water vapour flux from a surface which comprises enclosing a zone adjacent to the surface within a measurement cylinder open at both ends by placing one end of the measurement cylinder against the surface and measuring the relative humidity and temperature or quantities from which the water vapour concentration gradient and hence the water vapour flux can be calculated by means of at least two such sensor combinations positioned adjacent the wall of the measurement cylinder.

10. Equipment as claimed in any one of claims 1 to 8 in which the measurement cylinder has a first end which is open and a second end which is closed, the first end being adapted to be placed against the surface of interest and there being a means to cool the second end of the measurement cylinder. The measurement cylinder is provided with one or more relative humidity sensors and associated temperature sensors, which sensors are positioned adjacent the wall of the measurement cylinder. In use, water vapour escaping from the surface of interest diffuses along the measurement cylinder and passes the sensors. The output from these sensors can be used to measure the water vapour concentration gradient in the measurement cylinder and hence the water vapour flux from the skin.

11. Equipment as claimed in claim 10 in which the sensors are mounted in the wall inside the measurement cylinder.

12. Equipment as claimed in claim 10 where the sensors are mounted on the outside of the measurement cylinder and there is a hole through the wall of the measurement cylinder which hole and sensor and hole is sealed against the atmosphere outside the measurement cylinder.

13. Equipment as claimed in claim 10 in which there is a hole through the measurement cylinder wall and the sensors are mounted at least partially within such hole and the hole is sealed against the atmosphere outside the measurement cylinder.

14. Equipment as claimed in any one of claims 10 to 13 in which the closed end of the measurement cylinder is cooled to a temperature at which the water vapour in its vicinity condenses to liquid water or ice and steady conditions of water vapour diffusion are established within the measurement cylinder, with the concentration of water vapour in the immediate vicinity of the cold end of the measurement cylinder being lower than in the immediate vicinity of the surface of interest.

15. A method as claimed in any one of claims 10 to 14 in which the closed surface of the measurement cylinder is cooled by a cooling means based on the Peltier effect and water condensed at the closed end of the measurement cylinder is re-evaporated by heating the surface during times when the instrument is not being used for measurement by reversing the current through the Peltier effect cooling means.

16. A method for measuring the water vapour flux from a surface which comprises enclosing a zone adjacent to the surface within a measurement cylinder which is open at one end and closed at the other end by placing the open end of the measurement

cylinder against the surface of interest and measuring quantities from which the flux of water vapour from the surface of interest can be calculated.

Abstract

A method and equipment for measuring vapour flux from a surface e.g. the rate of water loss from human skin, which is useful in the evaluation of the efficiency of the skin/water barrier. It uses a measurement cylinder, one end of which is placed against the surface of interest to create a stagnant diffusion zone within the measurement cylinder. The water vapour flux is determined by measuring the gradient of water vapour concentration by means of sensors positioned adjacent the wall of the measurement cylinder.

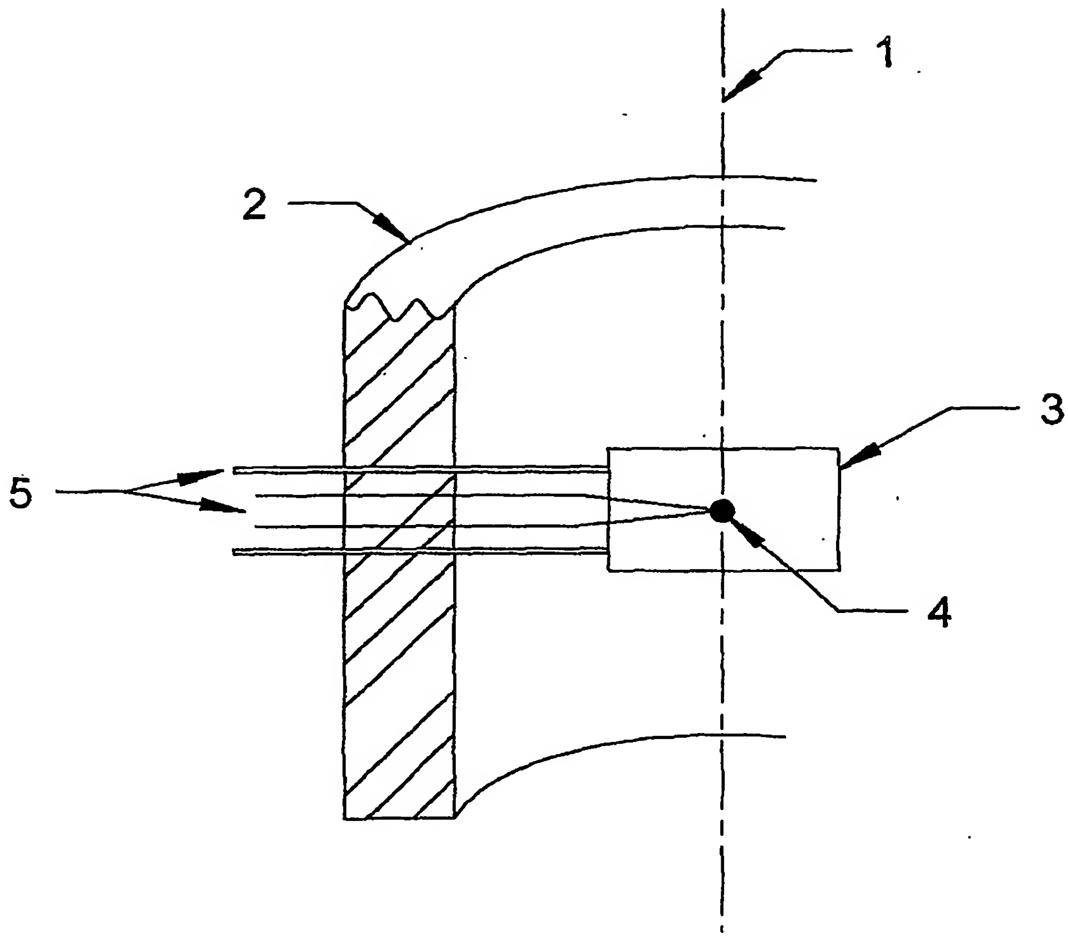

Fig. 1

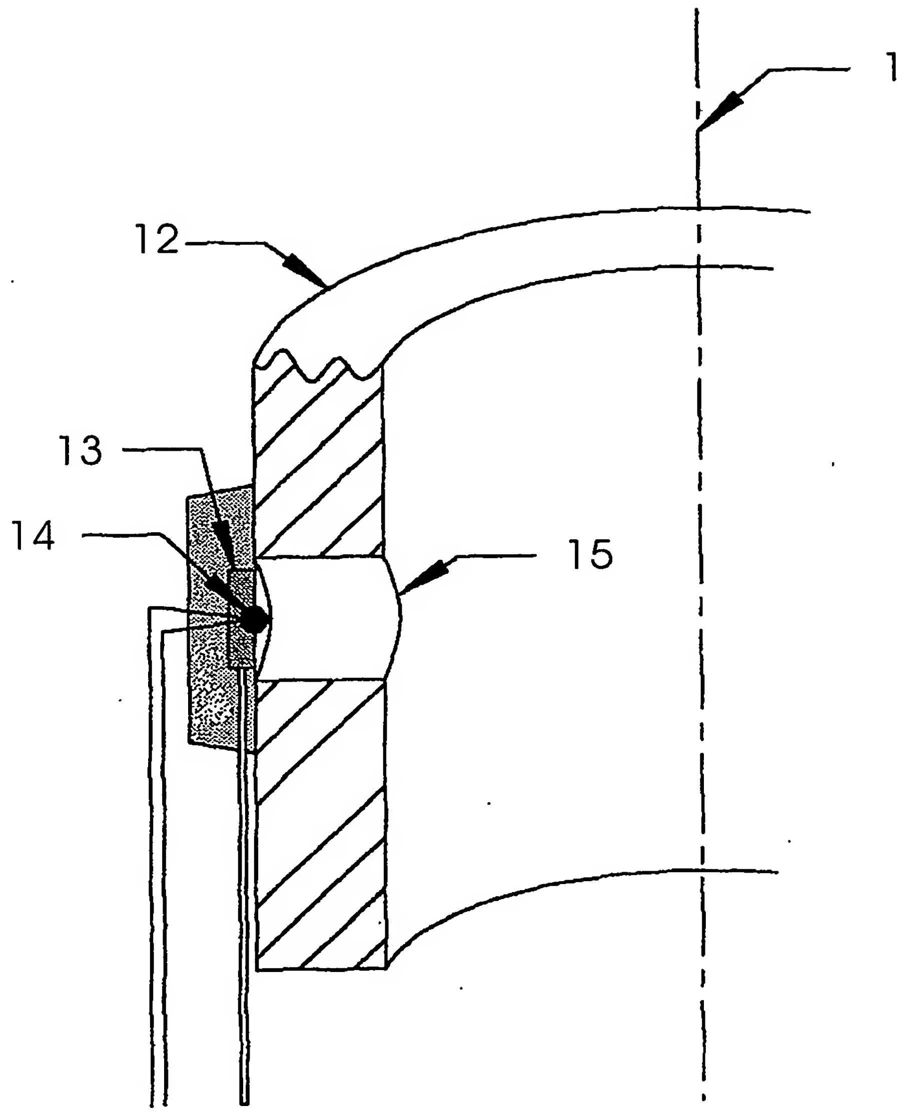

Fig. 2